



Mobile Off -Road Retrofit SCRT® System Demonstration Program

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Johnson Matthey

July 29, 2010



Johnson Matthey Overview



Johnson Matthey Plc



- British Company - established in 1817, London.
- Incorporated as Limited Company in 1891.
- Member of the FTSE 100
- Comprised of three divisions.
- Employing 7,700 people in 38 countries.
- Sales revenue of \$12 billion.
- Sole PGM marketing agent for Anglo Platinum formerly Rustenburg Platinum Mines Ltd.



Johnson Matthey Divisions



Johnson Matthey is a specialty chemicals company focused on its core skills in precious metals, catalysts, and fine chemicals. It is organized into three global divisions:



**Precious
Metal Products**



**Fine Chemicals
and Catalysts**



**Environmental
Technologies**



Johnson Matthey Precious Metal Products Division



- Platinum Marketing
- PGM Refining
- Gold & Silver Refining
- Bullion Products
- Color Technologies
- Jewelry

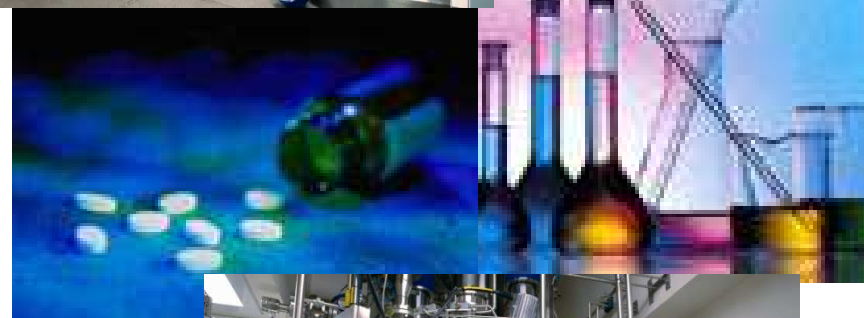
*Sole Marketing Agent for The
Largest Platinum Mines in South
Africa – Anglo Platinum*



Johnson Matthey Fine Chemicals & Catalysts Division



- **Catalysts and Chemicals**
- **Pharmaceutical Materials and Services:**
 - *Anti-cancer drugs*
 - *Controlled substances*
 - *Non-Controlled Products*
 - *Contract R&D and Manufacturing Services*
- **Research Chemicals**



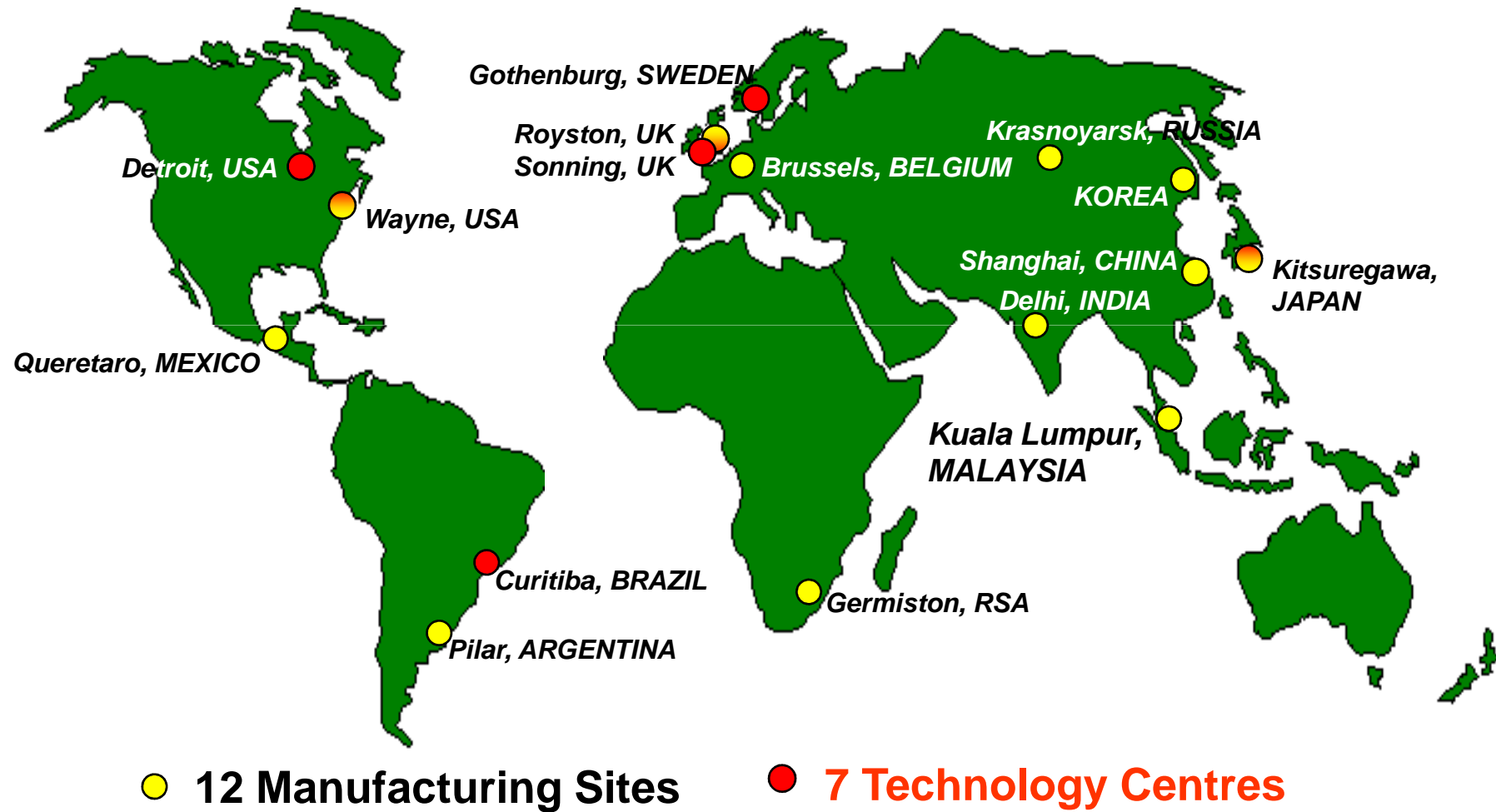
Johnson Matthey Environmental Technologies Division



- **Emission Control Technologies**
 - *Mobile*
 - *SSEC*
- **Process Catalysts & Technologies**
 - *AMOG*
 - *Davy Process Technology*
- **Fuel Cells**



Global Networks



Emission Control Technologies



- Comprises the autocatalyst, heavy duty diesel and stationary emissions control businesses
- Supply 35-40% of the world's auto catalyst
- JM's advanced NOx control technology, SCRT[®], has been listed on EPA's Emerging Technology List: in the process of being verified by the EPA and CARB
- The AdvCCRT[®] and CRT[®] Diesel Particulate Filter are EPA verified and CARB verified
- JM CRTs installed on over 5 million LDD vehicles and 1,000,000 HDD vehicles – OE & Retrofit
- JM DOC's installed on millions of LDD vehicles, 400,000 HDD vehicles, 12,000 urban buses, and 25,000 off-road equipment – OE & Retrofit
- JM technology supplied for US'07 and US'10 and Euro 4/5



ICAT Grant No: 06-06



GRANT OBJECTIVE



The purpose of the ICAT grant to JM was to demonstrate SCRT technology on two pieces of off-road diesel powered machines



What is it?

$$\text{CRT}^{\text{®}} + \text{SCR} = \text{SCRT}^{\text{®}}$$

CRT[®] = Continuously Regenerating Technology, JM's passively regenerating diesel PM filter technology

SCR = Selective Catalytic Reduction of NOx

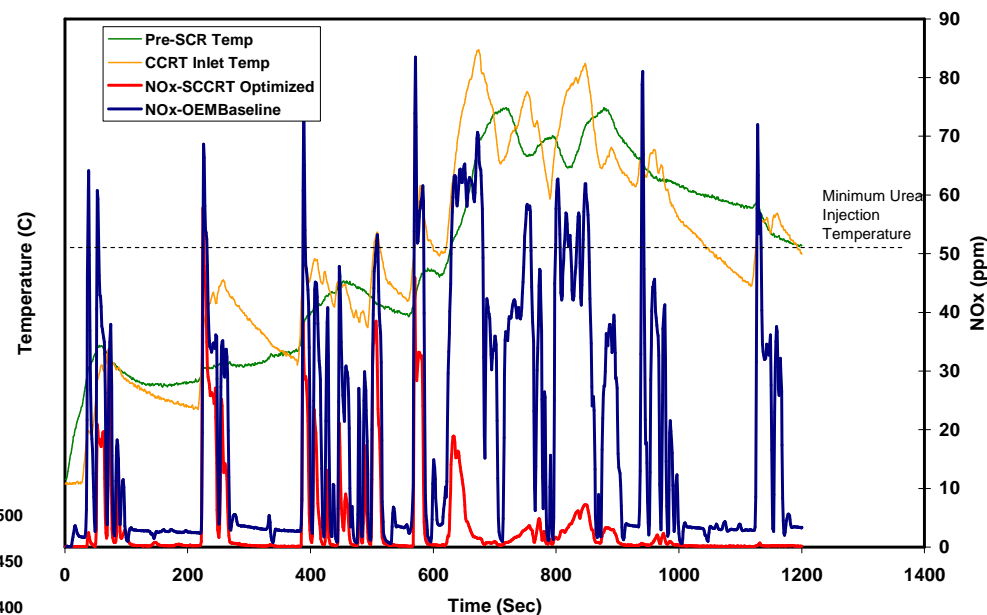




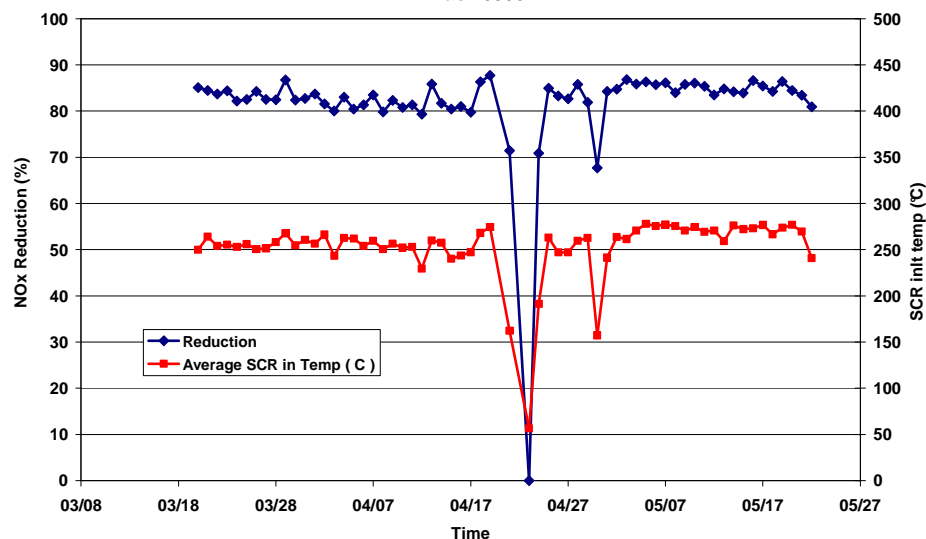
Why the SCRT System?

- Demonstrated on dozens of on-road applications
- Being considered for on-road verification with EPA and CARB
- Proven NOx reduction

HOT FTP Cycle - Optimized SCCRT
On Cummins ISM 280



Daily NOx Reduction and Average SCR inlet temp
Truck 5908



Selective Catalytic Reduction Technology (SCRT)

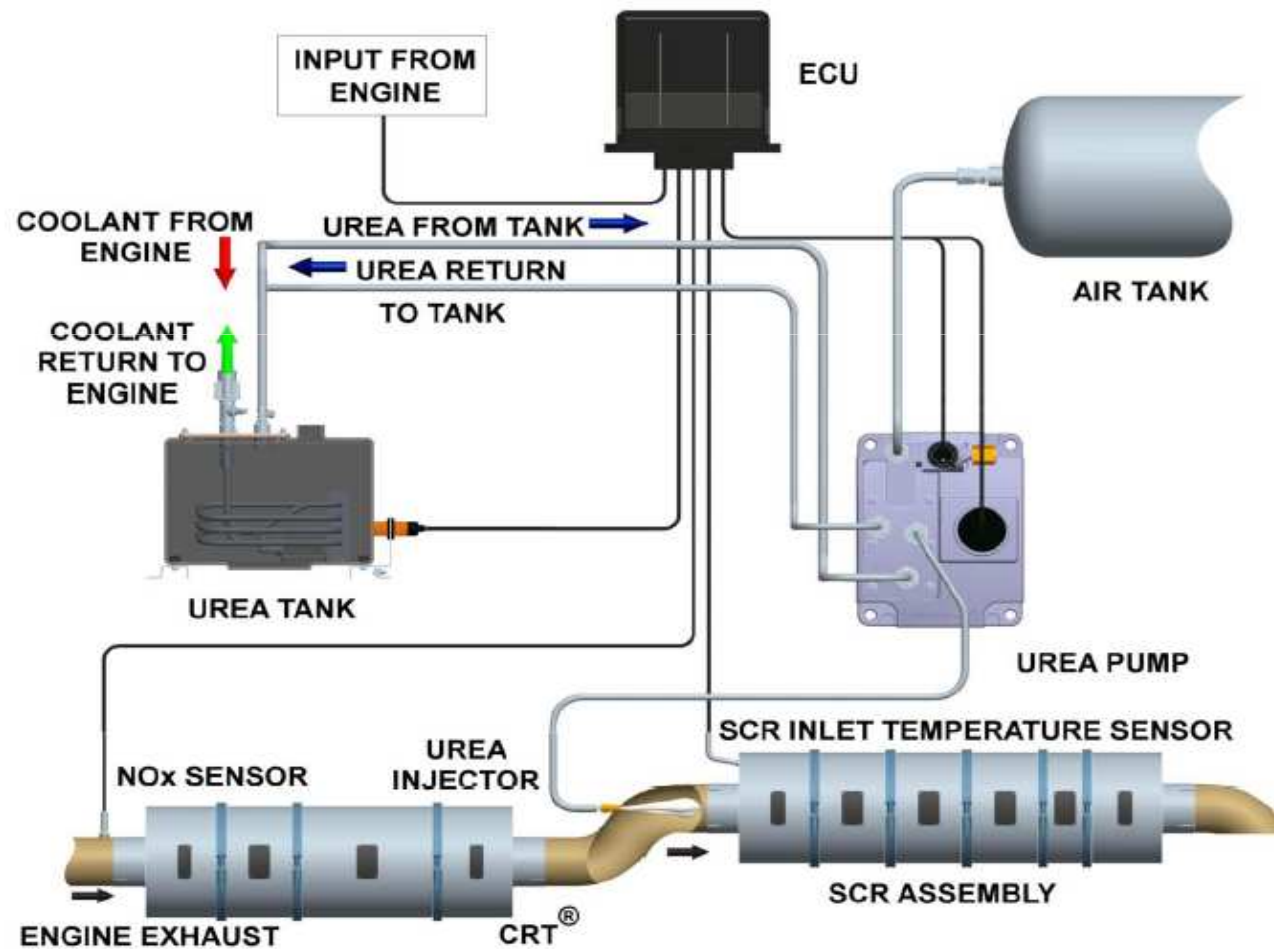
- A flow through SCR catalyst that uses ammonia for reduction of NO_x by 50 – 90%+
- Currently all systems inject DEF (urea) which is converted to ammonia when injected into the exhaust stream
- SCR catalyst typically contains no precious metals
- SCR is a mature, commercial technology that has been used in stationary applications for over 30 years and has been implemented in the US, Japan, and Europe for on-road vehicles
- SCR technology is applicable to LHD, MHD and HHD new engines and is the solution for a number of MHD and HHD platforms to meet the US EPA 2010 regulations
- SCR only systems are in use for Euro 4 and Euro 5 engines
- SCRT is a retrofit solution and several systems are in verification with the EPA and CARB



TECHNOLOGY DETAILS



Selective Catalytic Reduction Technology (SCRT)



TECHNOLOGY DEMONSTRATION



SCRT

Ozark / Raley's Truck 1555 (2.5g NOx engine)

System Description			
Vehicle	2005 Kenworth	Injector type	Grundfos
Engine	2005 CUM ISX 400 Hp 14 l	Sensors	IFM Efector Kavlico
CRT	8.5 l DOC	Primary Purpose	Performance evaluation/ Verification
	22l 200 cpsi coated filter	Installed	Aug 2007
SCR	25.5 l Zeolite	Other	
	4.2 l ASC		



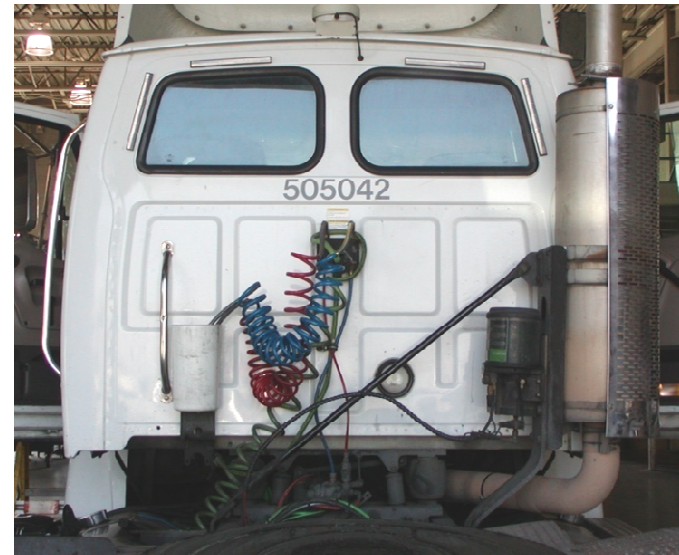
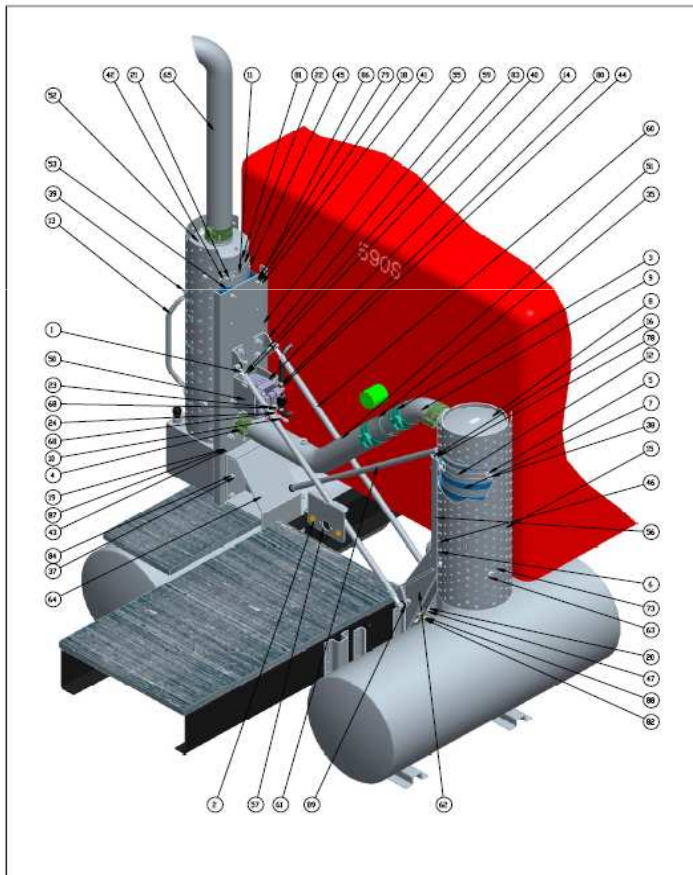
11/16/2007 - 1/23/2008	
NOx Reduction	80.6%
Hours run	191.3
Overall CRT P200	78.0%
Overall SCR P200	81.1%



TECHNOLOGY DEMONSTRATION



SCRT



MACHINE SELECTION FOR ICAT



Fleet Operator	Los Angeles Sanitation District (Carson)	
Operator Identification Number	8231	8239
Machine Make	Hyundai	Caterpillar
Machine Model	HL 740-7	966 GII
Model Year	2005	2003
Machine Identification Number	LF0110523	0AXJ01440
Engine Make	Cummins	Caterpillar
Engine Model	ISC	3176C
Engine Displacement	8.3 L	10.3 L
Engine Emissions Family	5CEXL0359AAD	3CPXL10.3ESK
Engine Power	140 HP	327 HP



MACHINE SELECTION



Caterpillar 966 GII

Hyundai HL740-7



SCRT SYSTEM DESIGN



Catalyst Components

Component	Hyundai	Caterpillar
DOC	1 - 10.5x6 DOC	1 – 11.25x5 DOC
DPF	1 – 10.5x12 CSF	1 – 12x12 Bare DPF
SCR	2 – 10.5x6 Fe Zeolite	2 – 12x6 Fe Zeolite
Slip Catalyst	1 – 10.5x3	1 – 12x4



SCRT SYSTEM DESIGN



Dosing Components



Dosing Pump	Grundfos Air Assisted
Dosing Nozzle	Grundfos
Controller	Custom ECU by STT Emtec with JM proprietary Dosing and Diagnostic Algorithm
Sensors	EO NOx Sensor (feed forward control)
	TP NOx Sensor (Datalogging, NOx Reduction Monitoring)
	Exhaust Backpressure
	Nozzle Line pressure
	CRT Temperature (inlet)
	SCR Temperature (inlet)
Urea Tank	Custom Stainless Steel
Air System	Ready Air AAA 12V electric compressor with 6 gal air tank reservoir



Factors Contributing to Design:

- Minimize Engine Turbo-to-Exhaust system Distance
- Proximity to Structural mounting points on the machine
- Availability of 12V power
- Availability of Compressed Air



Design Solution – Hyundai HL 740-7

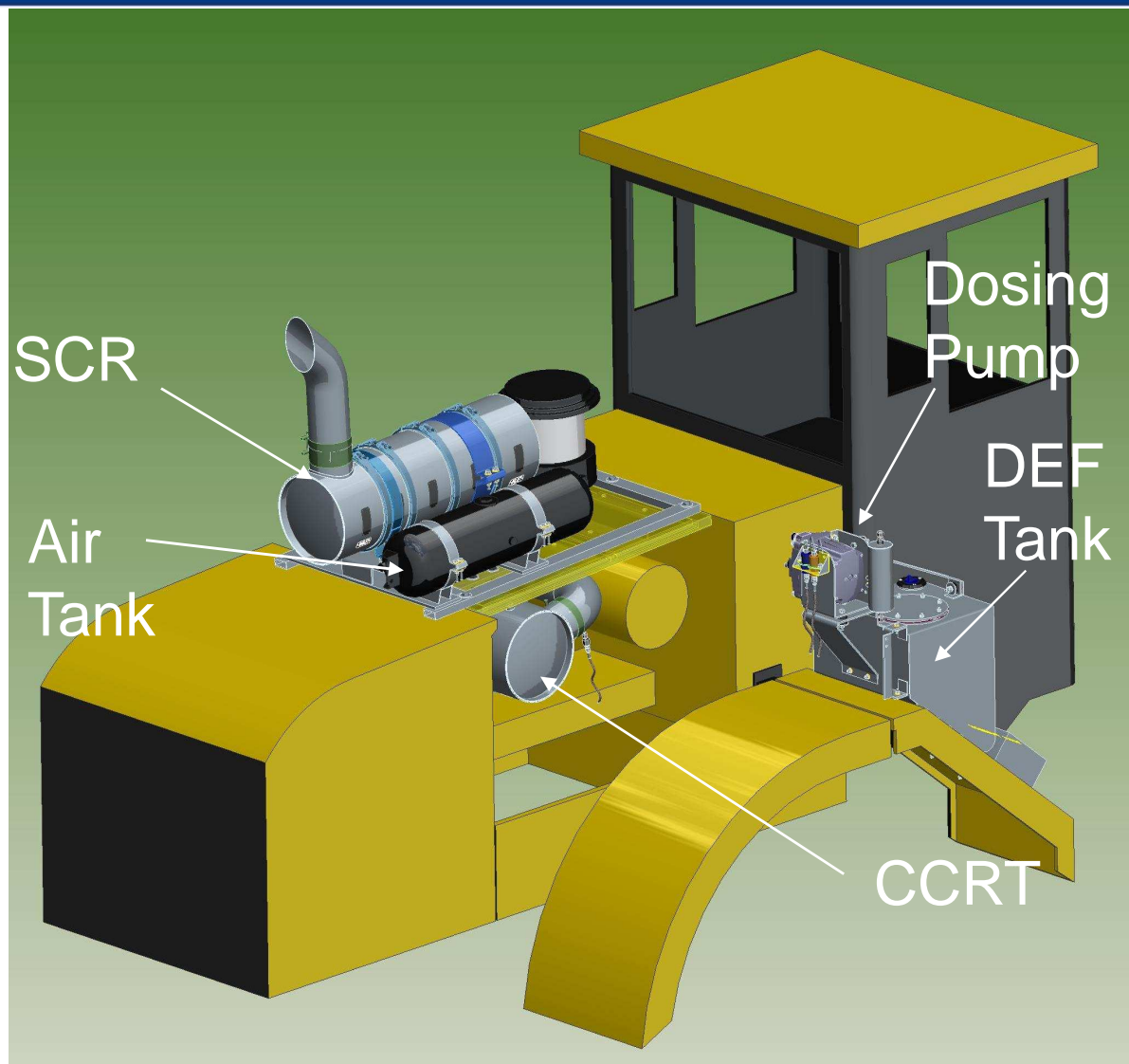


- Distance
 - Good – DPF mounted within 48 inches of the turbo outlet
- Proximity to Structural mounting
 - Good – Engine shroud made of structural members sufficient to support CCRT and SCR modules
- Availability of 12V Power
 - Ok – Machine operates on 24V, but uses two 12V batteries in series, so power was connected between ground and 12V terminal
- Compressed Air Availability
 - NO! – Procured a mobile air compressor system with a reservoir tank



Design Solution – Hyundai HL 740-7

- CCRT® filter mounted in Engine compartment
- SCR mounted on top of the engine compartment
- DEF Tank and Dosing System mounted adjacent to cab on Wheel Fender



Design Solution – CAT 966 GII

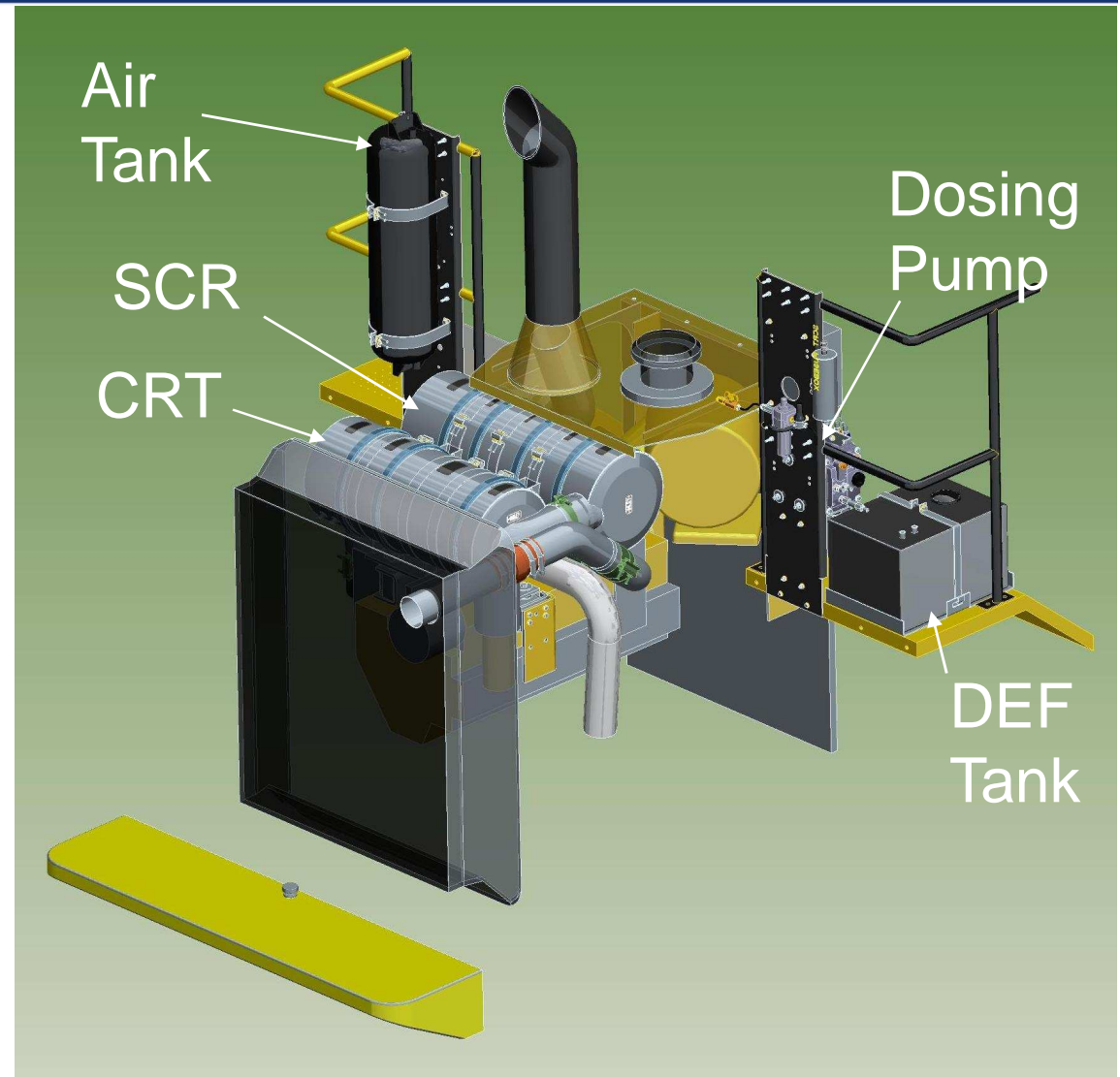


- Distance
 - Excellent – DPF mounted within 15 inches of the turbo outlet
- Proximity to Structural mounting
 - OK – Engine shroud NOT made of structural members.
Special mounting had to be designed to Engine Block/Head
- Availability of 12V Power
 - Ok – Machine operates on 24V, but uses two 12V batteries in series, so power was connected between ground and 12V terminal
- Compressed Air Availability
 - NO! – Procured a mobile air compressor system with a reservoir tank



Design Solution – Caterpillar 966 GII

- CRT® filter and SCR mounted in Engine compartment
- DEF Tank and Dosing System mounted adjacent to cab on Wheel Fender
- Air Tank and Reservoir mounted adjacent to Operator Entry on Railing



- DPF installed on October 30, 2008
- SCR installed on August 14, 2009
- Hyundai Unit operated satisfactorily upon installation
- CAT Unit was not able to communicate with the SAE J1939 network with the engine



- CAT J1939 Communication Problem
 - JM's On-road experience with CAT Engines
 - CAT Wiring Diagram
 - showed only a CAT Data Link
 - NOT SAE J1939
 - CAT Proprietary use only
 - Contacted CAT Distributors for a solution
 - Solution not available



System Installation – Hyundai HL 740-7



System Installation – CAT 966 GII



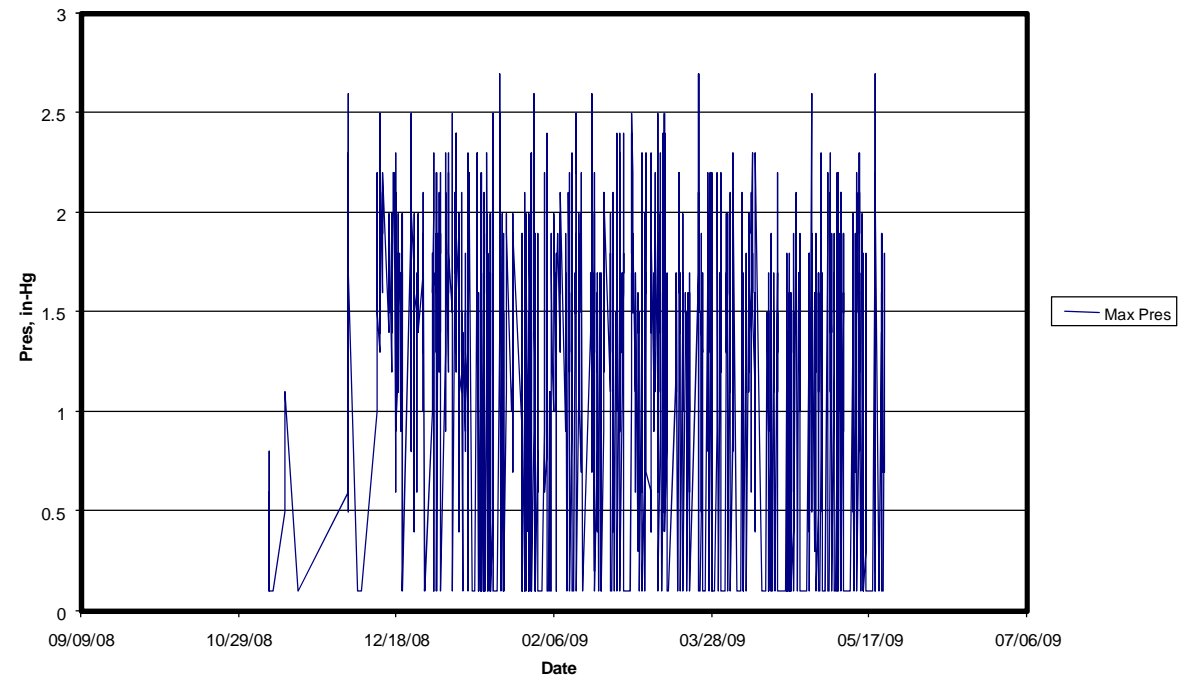
System Performance – Phase I



ICAT, LASD, Hyundai Front-End Loader
May 21, 2009

Hyundai Unit

- Backpressure stable
- 93.5 hours of operation over 6 months
- CCRT filter was operating properly



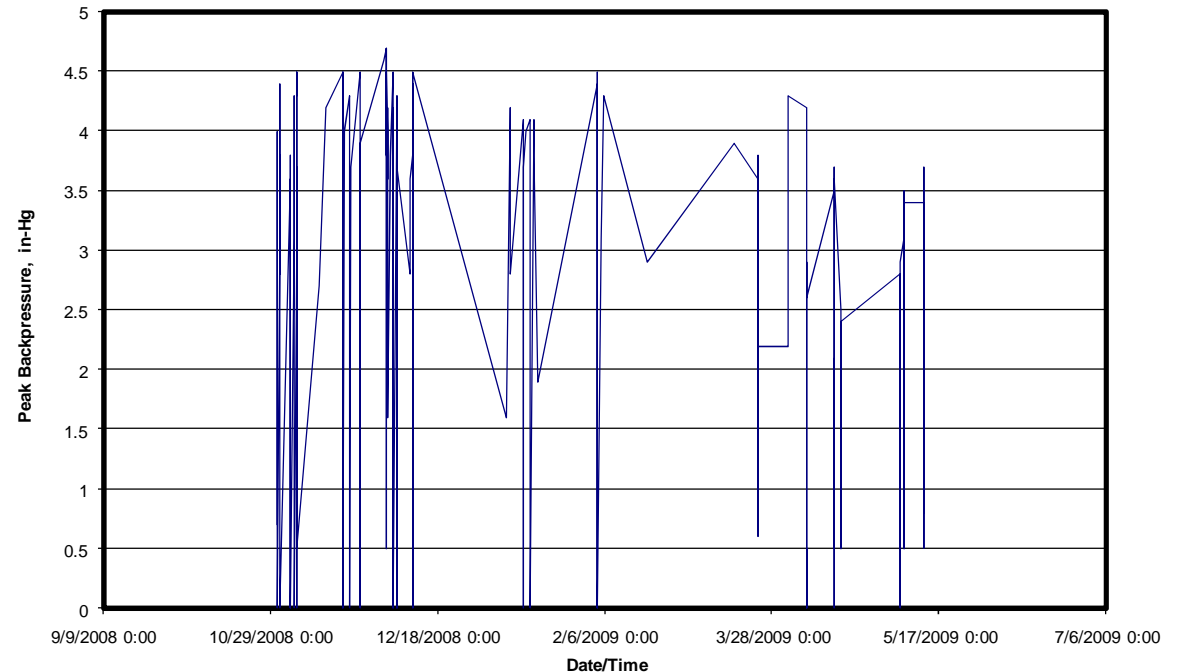
System Performance – Phase I



ICAT, LASD, Caterpillar FEL
5/21/2009 Download

Caterpillar Unit

- Backpressure stable
- 43.5 hours of operation over 6 months
- Indicates CRT filter was operating properly

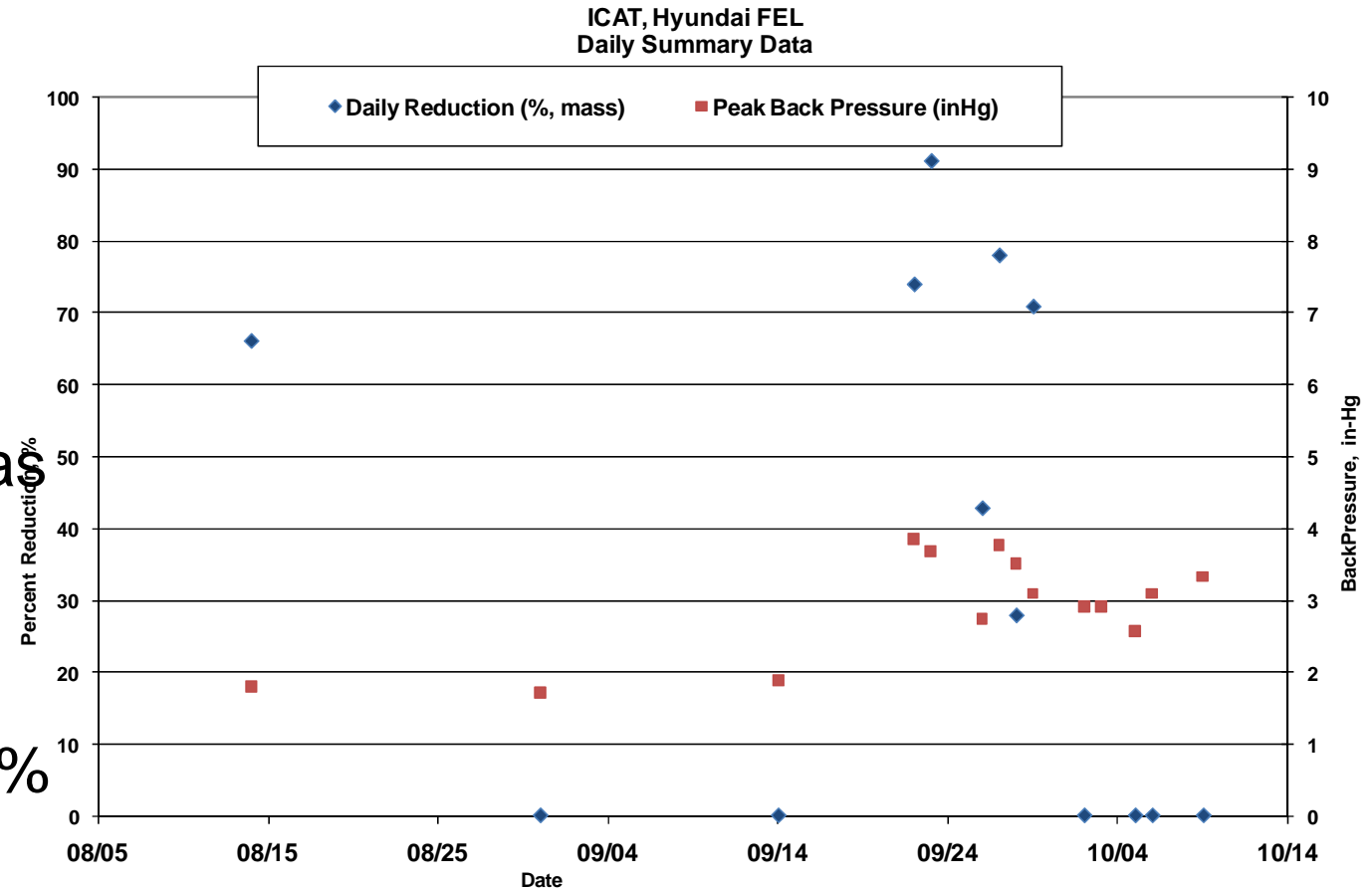


System Performance – Phase II



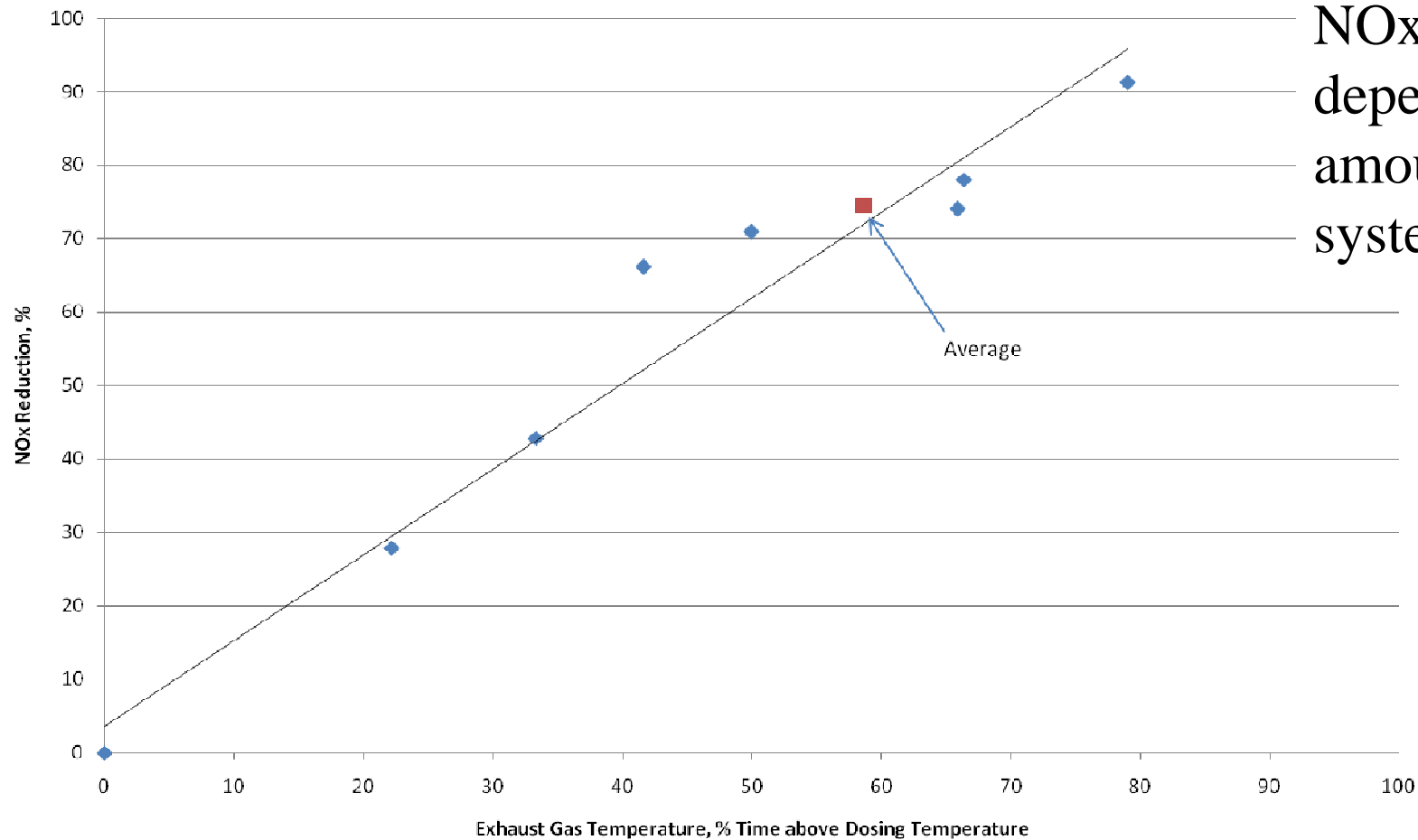
Hyundai Unit

- Backpressure stable
- 9 hours of operation
- CCRT filter was operating properly
- Average NO_x Reduction = 74%



System Performance – Phase II

ICAT, LASD, Hyundai FEL
NOx Reduction vs. Dosing Temperature



NOx Reduction depends on amount of time system is dosing



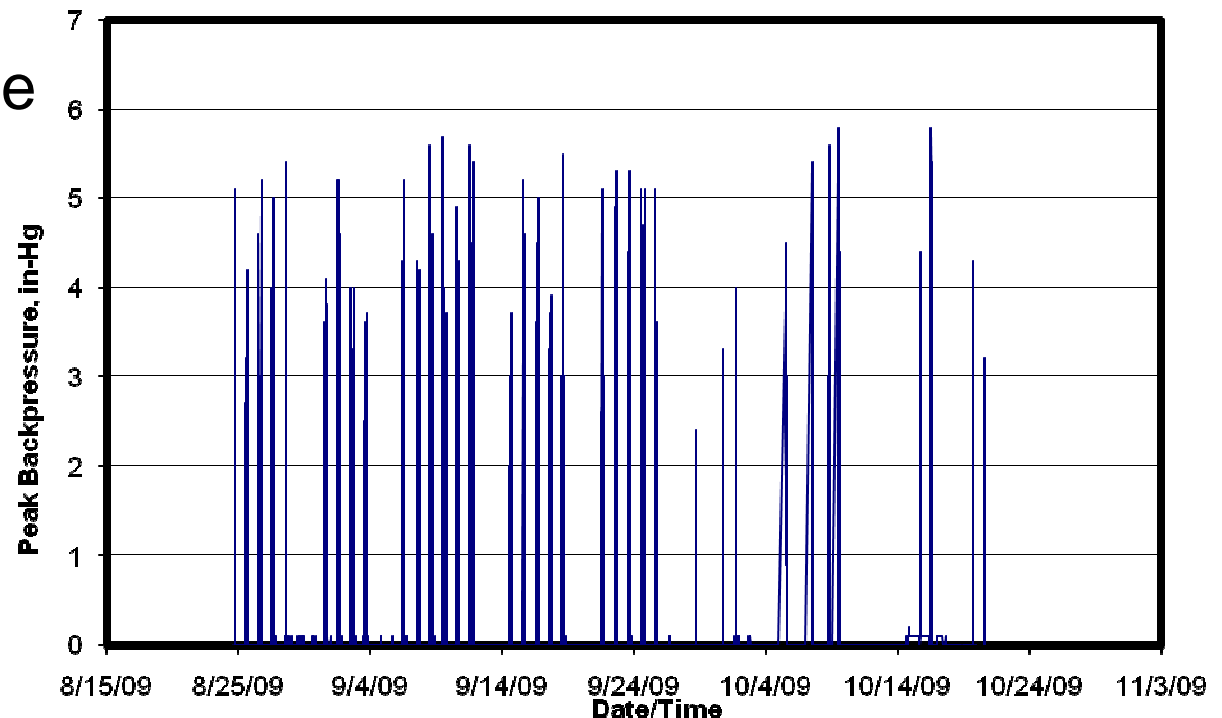
System Performance – Phase II



ICAT, LASD, Caterpillar FEL
10/21/2009 Download

Caterpillar Unit

- Backpressure stable
- 32 hours of operation
- CRT filter was operating properly



Hyundai Unit

- October 2009 – LASD Arranged Service for non-SCRT related issue
- After service, SCRT system stopped operating
- JM discovered issue during January 2010 inspection
- Investigation revealed the system was re-wired to 24V system
- Caused over-voltage to critical components of SCRT system. System malfunctioned and stopped operating.



Caterpillar Unit

- No SAE J1939 Datalink found on machine during system installation
- Contacted CAT Distribution network
- After investigating, CAT distributors were not able to identify a solution for communication



Operator Worksite Visibility

- Not identified as a requirement at beginning of project
- Became apparent during discussions with Distributors knowledgeable with off-road markets
- Will need to understand requirements prior to integrating technology on future projects
- Cal/OSHA looking to revise Title 8 language for safety/visibility
- May limit available space for mounting components on machine chassis



Summary



- CRT and CCRT Diesel Particulate Filter systems operated well on the chosen off-road applications
- The SCRT system demonstrated > 70% NOx Reduction on the Hyundai machine
- Effective design of SCRT system enabled retrofit installation within a tight packaging envelope
- The SCRT system on the Caterpillar machine was not operational due to the lack of the J1939 datalink
- SAE J1939 datalinks may not always be available on off-road machinery
- Emissions control equipment should be designed to accommodate a wide range of operating voltages found on off-road equipment
- An on-board compressed air option should be made available for off-road equipment



- Questions??

